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MDA Update

Linking American Businesses to Missile Defense Technology
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INSIDE

A Glimpse at Technology's First Draft —*by Patrick Hartary*

Small technology companies try to invent their way into missile defense systems while thinking of future commercial prospects.

Innovate! That's MDA's prime directive to small technology companies undertaking early-stage research in its SBIR program.

To innovate, these companies must test the scientific and technical merit of a particular concept—for example, a faster way to acquire and track an enemy missile. Interestingly, this concept might also prove marketable in other "nonmilitary" uses, such as detecting breast cancer, inspecting gas pipes for leaks, or evaluating semiconductor bonds without destroying them.

Since its inception, the MDA SBIR program has awarded thousands of Phase I contracts for early-stage research. Below is a sampling of the newest projects undertaken. In each project, the small technology company proved their theory and not only produced a technology potentially valuable to MDA, but also to industry. Note that all three MDA-funded technologies are in various stages of development.

Nitride and Carbide Composite Zones in Metals

JET Technologies, Inc. (Locust Grove, VA), has developed a method of forming gradient nitride and carbide composite layers in metals, most notably titanium and aluminum. This method is different from other processes that simply convert a thin layer at the surface or apply a coating. For example, JET's process can be used to create a gradient titanium nitride composite up to 0.250-inches thick in titanium objects and a gradient aluminum nitride composite up to 0.05-inches thick in aluminum objects.

JET's innovation involves melting a given depth of metal using a proprietary plasma process and infusing it with the proper amount of reactants to create the desired composite layer. Others can perform a similar process, whereby they melt the surface and embed ceramic particles or fibers in the melt. According to JET, their manufacturing process is 3- to 20-times less expensive than these competing methods, when the cost of the initial facility, extra materials, and the cost of labor are considered.

The challenge for JET Technologies is to identify military and commercial applications for its technology. The JET Process offers the potential to decrease the overall weight, increase the strength, and increase the wear resistance of critical MDA components. Similar applications exist for industry. For example, wear-resistant components for manufacturing can be made without requiring fibers or particles. One drawback is that the process leaves a slightly rough surface. If required, this surface can be polished.

Tough stuff. *JET Technologies' process grew one-eighth of an inch of titanium nitride inside a U.S. Army tank center guide made of a titanium alloy. Tests showed a significant increase in wear resistance.*

In a recent demonstration, the JET process created titanium nitride wear surfaces on titanium center guides for U.S. Army tanks. Follow-up surface modification was not required because the as-processed surface

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MDA Update

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FROM THE EDITOR

WHY IS MDA FUNDING THAT?

I recently attended a party and, of course, the obligatory question "What do you do?" came up. With great pride, I explained that I'd just written a new report featuring high-tech products recently introduced into the marketplace.

"What kind of products?" the woman asked, curiously raising her eyebrow. I offered an example. "One of the products is a light-weight, compact escape mask that protects victims of accidents and terrorist attacks from inhaling harmful smoke and other hazardous airborne threats." To peak her interest, I added "The mask was made possible through research funded by MDA, the Missile Defense Agency."

With a slight grimmace, she retorted, "Why is MDA funding *that*?"

Actually, MDA didn't fund the development of the mask. But what this conversation does reveal is a common misconception by some people about what MDA really does fund.

The truth is MDA isn't interested in developing escape masks. However, it *is* interested in developing innovative technology—technology that's so ahead of its time, it might not even exist. Building superior defenses against ballistic missile attack requires the most sophisticated technology. The challenge of intercepting missile threats in flight has been compared to "hitting a bullet with a bullet." Nothing like this has ever been done before.

Let's return to the example above. In the 1980s, MDA's predecessor, the Ballistic Missile Defense Organization or BMDO, funded Auburn University to create a new carbon-metal composite. This material could be used to make powerful energy-storing devices, called capacitors, for the lasers, railguns, and other weapon systems BMDO was planning to build at the time. Later, Auburn University realized the composite's electrical properties and high surface area would allow it to trap particles more effectively than current methods. Recognizing the potential of the composite as a filter, it established a licensing agreement with IntraMicron, which used the material to develop the filter for the escape mask.

Together, Auburn University and IntraMicron developed the escape mask. The carbon-metal composite, which is key to the escape mask, was made possible with funding from MDA (then known as BMDO). More information about the escape mask and 23 additional MDA-funded technologies that have reached the marketplace are contained in the MDA *2002 Technology Applications Report.*

Before we parted, the woman asked if she could get a copy of the report. "Sure," I said smugly, handing over my business card. "E-mail me your address and I'll drop one in the mail." "Great," she replied as she trotted off to mingle with the host. "If you know anyone else who wants a copy, let me know," I shouted.

I would like to encourage you to do the same. If you would like to receive a free copy of the MDA *2002 Technology Applications Report*, see page 16.

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MINIATURE KILL VEHICLES—FINESSING PERFECTION

To destroy a missile accompanied by decoys in space, an interceptor system does not need brawn so much as it needs brains. In fact, studies have shown that a kill vehicle weighing no more than 2 to 5 kilograms can destroy warheads in midcourse. The real challenge of missile defense has been the need for near-perfect discrimination, including the likelihood that the first time our defense sees an enemy's missile system is also the first time the missile system is used against us. How does MDA solve the countermeasure problem of destroying threat missiles in a cloud of warheads and other objects? How can it defend against lethal objects and high-fidelity decoys in the threat cloud with little advanced information about them?

MDA's Advanced Systems Directorate is developing a concept called the Miniature Kill Vehicle (MKV), which is designed to be highly effective against countermeasures that previously seemed daunting. In this concept, a launched carrier vehicle releases 10 to 30 low-cost MKVs weighing little more than 5 kilograms in space. After conventional discrimination by currently planned radar- and space-based systems, the carrier vehicle assigns individual MKVs to all credible targets remaining in the threat cloud, which the MKVs then intercept and destroy by hypervelocity impact. This approach reduces the burden on discrimination and increases the effectiveness of the BMD system.

The idea of an MKV system is not new; however, it was not until the revolution in miniaturization over the past decade (such as MEMS, ever-shrinking computer chips, and miniaturized optics) that the concept promised to be so effective and affordable. Issues such as feasibility, lethality, and cost have been addressed. Viable design concepts recently developed by three competing teams have demonstrated the feasibility of MKV as well as critical hardware. In addition, Government-funded studies have shown very good lethality against warheads in midcourse flight, while independent cost analyses have shown high cost-effectiveness, especially as the number of credible threat objects grows beyond one or two.

MKV complements a range of technologies being targeted to protect against missile attack in the boost phase, midcourse, and terminal stages. For more information about MDA's programs and successes, see http://www.acq.osd.mil/bmdo/bmdolink/html/.

"We now have a viable alternative to perfect ballistic missile discrimination: Discriminate as best as possible and kill the rest," commented Dr. Walter Dyer, MDA's Technical Advisor for Advanced Systems.

PRESTIGIOUS AWARDS RECOGNIZE TECHNOLOGY INNOVATION AT MDA-FUNDED COMPANIES

Technology innovation isn't about winning awards. It's about finding practical applications of science. It's about creating and introducing new products into the marketplace. It's about succeeding in the highly competitive business world.

Significant technology innovation, however, needs to be recognized. In 2002, 22 companies with MDA research and development funding were honored with prestigious awards. More than half received the Small Business Administration's Tibbetts award, given annually to small firms, projects, organizations, and individuals judged to exemplify the very best in SBIR achievement. Eight more collected R&D 100 awards, bestowed upon companies and individuals introducing the 100 most technologically significant new products during each calendar year.

Below are the names of the 22 companies with MDA research and development funding that won awards during 2002.

Tibbetts Award Winners

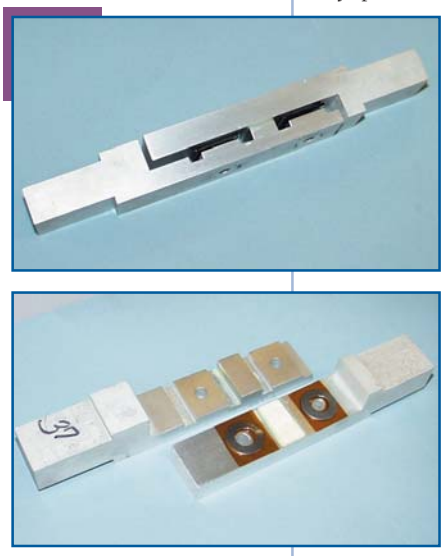
Advanced Optical Systems
Applied Physical Electronics
Barron Associates
Brewer Science
Browne Technology
Creare
CSA Engineering
Karta Technologies
Luna Innovations
nPoint
QRDC
Radiation Monitoring Devices
Structured Materials Industries
Systems & Processes Engineering

R&D 100 Award Winners

Advanced Ceramics Research
AstroPower
Cape Cod Research
Inovati
Nomadics
Simpex Technologies
Srico
Wavefront Sciences

Award winner. *Structured Materials Industries' president Dr. Gary Tompa (middle) receives his 2002 Roland Tibbetts Award from the U.S. Small Business Administration.*

DISBONDING TECHNIQUE TAKES JOLT OUT OF DISASSEMBLY



Charge it. *These images show EIC's prototype release mechanism. In the top image, the two pieces of the mechanism are bonded together with the company's epoxy adhesive. In the bottom image, the pieces have been electrically disbonded.*

Removing and replacing critical parts on cars, industrial equipment, aircraft, and satellites soon could be as easy as flipping a light switch.

The disassembly process—removing one object attached to another object—can be a tricky process. Disassembly can involve systems of clunky latches, bolts, and other fasteners. Or it can be a messy process, involving hammers and torches, and requiring the partial or complete destruction of equipment components. And in the case of separating spacecraft modules, it might even involve controlled explosions. Assembly also can be a destructive process. Adding a temporary structure to an aircraft, for example, could require drilling holes in a wing or fuselage, possibly undermining the structural integrity of the aircraft.

EIC Laboratories, Inc. (Norwood, MA), sees benefits in making bonding and disbonding processes neater and simpler, and the company has developed an electrically disbonding adhesive mechanism to do just that. The range of applications targeted is potentially huge. Bonded parts abound in products as common as automobiles and as complex as satellites. Meanwhile, the lure of more sound structures as well as cost savings from reusable components could prove to be big selling points for users in search of less destructive bonding and disbonding techniques.

EIC's bond-and-release technology, called ElectRelease™, includes a high-strength epoxy sandwiched between metal substrates. The epoxy can support more than 2,000 pounds per square inch. Applying between 10 and 50 volts of electricity to the mechanism causes the epoxy to disbond, cleaving the "sandwich" into two pieces—one clean substrate and one substrate with the epoxy still attached.

EIC officials say users of their low-shock release mechanism will need only a thin, light layer of the epoxy, offering a weight advantage over heavy conventional fasteners such as metal bolts. Users can apply the epoxy in layers as thin as ten one-thousandths of an inch, according to the company.

The ElectRelease mechanism could work to remove wildlife tags from animals or to attach and then remove temporary components to equipment during the manufacturing and testing phases. The technology also holds promise for use in space, where the low-shock release mechanism could replace the explosive mechanism often used to detach the components of a spacecraft or satellite. Explosives and other detachment techniques could jar a satellite, damaging it or slightly altering its intended path. "You want very little shock to jar electronics or optics and you want very little shock to induce any rotation of that satellite," said Dr. Stuart Cogan, EIC's vice president of advanced materials.

MDA's predecessor, BMDO, funded EIC's technology for potential use as a release mechanism in launch vehicles. EIC anticipates commercial opportunities for the technology throughout the Department of Defense and NASA, as well as in private-sector launch vehicles and satellites.

Company officials continue to refine their product and seek new markets and appropriate applications. "We would like to see a considerably shortened cure time for these epoxies so that they would be much more amenable to a high-volume manufacturing operation," said Cogan. Once the refinements are made, finding a contractor to produce epoxies in large batches should not be difficult, he added. Cogan said the company already has introduced ElectRelease as a commercial product and expects to have a marketable, rapid-curing product within the next one to three years, at which time licensing of the technology will be a strong option.

—S. Tillett

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BORON NITRIDE POWDER IMPROVES HEAT FLOW

Waste heat is the enemy. Boron nitride powder is a new ally.

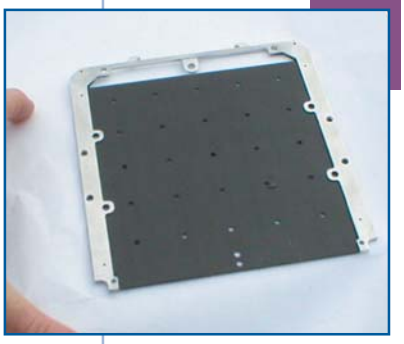
XC Associates, Inc. (Stephentown, NY), invented a new material that can whisk away waste heat at twice the efficiency of aluminum or at less cost and weight than beryllium. The company has patented equipment that reliably salts carbon fiber sheets with boron nitride powder and then laminates two or more plies together. The resulting material is used in lightweight heat sinks, from which spacecraft radiators or missile electronics or parts could benefit.

The company started experimenting with adding boron nitride powder into laminated fiber sheets in the late 1990s, suspecting that it might improve thermal conductivity. BMDO, now MDA, awarded a Phase I contract to XC Associates in 1998 to study all of the potential benefits. Researchers determined that the powder, when properly applied, improved efficiency of heat flow over untreated laminates by a factor of four. The salting process also had a fringe benefit of improving laminate stiffness. In 2000, BMDO awarded a Phase II contract to the company to design and fabricate prototype components that would then be qualified by potential users and eventually sold to them as part of their avionics or space systems.

As with making lasagna, the trick to making improved heat sink carbon fiber is in applying the ingredients in the right places. High thermal conductivity fiber spreads heat very well in the direction of the fiber, but not very well in the transverse directions (up and down). Boron nitride is a hexagonal, flat-plate molecule and forms into crystals. The crystals can carry heat very well from one fiber ply to the next. Salt a thermoset resin carbon fiber sheet (called "prepreg") with boron nitride crystals, layer another prepreg sheet on top of that, repeat the procedure, laminate the whole thing together, and you create a material that is capable of transferring heat down through the sink as well as away towards the edges.

Getting just the right amount of powder into the mix turns out to be another key. Use too little, and it doesn't have enough effect. Use too much, and the laminate tends to fall apart. XC Associates' application mechanism has improved since the early days when researchers applied the powder "using something like a sugar shaker" according to company president John Bootle.

The improved laminate is not a theoretical product. XC Associates is working in partnership with the Applied Physics Laboratory of the Johns Hopkins University to provide a heat sink for a radiator component on a Mars explorer spacecraft. Raytheon Missile Systems was also interested in testing the properties and reliability of a salted composite carbon fiber heat sink as a potential replacement for the heavier beryllium-based heat sink in the LEAP missile program. Raytheon determined that the composite could remove heat as well as a sink made of beryllium, for a third of the cost. Other major aerospace corporations as well have expressed interest in the new material and await its spaceflight qualification.



Salt-n-prepreg. *XC Associates have created a lightweight heat sink material using laminated "prepreg" carbon fiber sheets salted with boron nitride powder.*

Because making this improved carbon fiber sheet is expensive, laminates incorporating boron nitride powder crystals may never replace simple aluminum heat sinks for many applications. For machines producing large quantities of heat in confined areas, in which air-cooling is not an option, composite fiber heat sinks may be optimal. A six-inch square card, for example, can handle a heat flux of anywhere from 50 to 75 watts; an aluminum heat sink of equal thickness would only be able to handle a 40-watt flux.

This novel laminate is a solution seeking a problem. XC Associates invites engineers or program managers who have system design thermal and weight constraints to contact the company to see if composite laminates can help.

—A. Gruen

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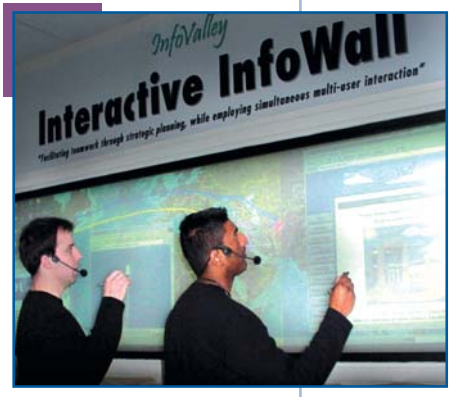
COMPUTING

DISPLAY WALL GIVES APPLICATIONS THEIR SHOT AT THE BIG SCREEN



Untethered. *InfoValley display wall technology could help manage military projects. The technology could apply to homeland security applications, command centers, and cyber-warrior training, as well as computer network-management centers or broadcasting control rooms.*

In coming years, the omnipresent conference-room whiteboard could be replaced by a giant interactive computer screen that allows multiple workers in a room, or even in remote locations, to collaborate on projects.

InfoValley Corporation (King of Prussia, PA), with funding from MDA, has developed computer interface technology that gives a team of workers simultaneous access to a large display wall that serves as sort of a common computer screen. The workers also can access their own individual computers using a window on the display wall to work with their applications.

In effect, the wall functions as a second, giant computer screen. Activity on the wall, called the Interactive InfoWall™, mirrors the activity on a user's desktop or laptop computer—much in the same way a lecturer might use a laptop and a multimedia overhead projector to deliver a presentation.

But the wall allows several users to access the display at the same time. So an entire team of workers, for example, might display information from their individual computers side by side on the wall. The users do not even have to be in the same room. One or more of them could be based at a remote location and still contribute and access InfoWall information—as long as that remote user is connected to the same network as other users of the wall. InfoValley calls its interface the Team Computer Interface.

MDA, through the SBIR program, funded the technology for possible use in battle management and command and control. The collaborative interface builds off of InfoValley technology funded by the Air Force Research Laboratory. That technology, called the Multiple Simultaneous User Interface Technology, allows several users to simultaneously interact with the wall using coordinated voice commands and laser pointers.

A typical Interactive InfoWall includes a rear-projection screen measuring roughly 3 by 12 feet, displaying a composite of three projected displays. This setup—which includes a special computer system called a "display controller," networking, software, wireless microphones, and laser pointers—could cost between $50,000 and $100,000, depending on the level of service and equipment the customer needs. The wall could be expanded to display a composite of as many as 44 or 128 projected displays, depending on the operating system.

By creating such a large high-resolution information-display "canvas," users don't have to huddle around the single small screen of one user's desktop when collaborating on a project. And users can see multiple information displays or computer applications running side by side, instead of toggling among applications on small computer screens.

"A single desktop computer display is often too small to use in decision-making meetings," said Dr. Sakunthala Gananamgari, the company's president. "InfoWall provides a much larger computer work space, allowing team members to simultaneously present their information."

Another feature that sets the InfoValley technology apart from conventional computer-based collaboration is "untethered" interaction. Users of the wall can navigate applications and access data using coordinated voice commands and a laser pointer instead of a mouse. These tools allow a user such as a lecturer to share information with a group without being confined to a desktop control panel.

InfoValley executives hope the technology will hold promise for remote learning, as well as for meeting planners, office managers, or other users of teleconferencing equipment. A tool such as the InfoWall could allow students to share their work instantly with an instructor and with classmates, or it could allow an instructor to use several computer applications running side by side when teaching a class.

InfoValley continues to seek partnerships, customers, and other avenues for marketing the technology.

—S. Tillett

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COMPUTING

SECURING IDENTITY AND INFORMATION IN THE INTERNET AGE

Smart cards. Smart networks. Smart weapons. Get ready for smart content.

Avanza Technologies, Inc. (Los Alamos, NM), with the help of MDA SBIR funding, has created software called Managed*i™ that helps securely manage information, identity, and the way both are exchanged across a physical network. Every transmission contains its own instructions for handling and use, as if it were a letter that refused to be delivered into the wrong hands but could use anyone as a postal carrier. As long as the network itself is not destroyed, no matter how many nodes are damaged, secure communications can proceed.

MDA, and many others in the U.S. defense and intelligence community, have an interest in creating secure communications using "virtual" networks as opposed to private networks. In 2002, MDA awarded a Phase I SBIR contract to Avanza to develop project SCORE (Secure Communication Object Repository Environment), to show how a robust and secure peer-to-peer network environment could integrate diverse data sources. Recently, MDA invited Avanza to submit a follow-on Phase II proposal.

The whole key to Managed*i is that the transmission of content doesn't rely on a single specific or administrative Internet server. Every machine or appliance in a network becomes a potential "node" and a mechanism for routing a transmitted packet on to its intended destination. In the Managed*i universe, a transmission is secured with binary logic code and encrypted before it is further clarified by an XML (Extensible Markup Language) standard. Only when verification of both the acceptable sender and receiver takes place does a set of data packets then proceed to an XML, HTML, or HTTP stage.

In short, when a message, document, or database is created, the person creating it defines exactly how it will be read and by whom, and for how long and under what conditions. Likewise, the person receiving it defines exactly under what conditions such transmissions will be accepted. Someone with authority to read a document would be unable to send it to someone else, unless the original owner establishes permission to do so in the document itself. Changes in permission could be made via updates.

The implications for electronic commerce are substantial. Working under a Managed*i system, "spam" (junk e-mail) would be impossible. Piracy would also be impossible. For example, a music company could transmit an MP3 file to you, but you would not be able to retransmit it to anyone else. In return, your privacy in downloading that particular file would be guaranteed. Individuals would be able to control their own medical and credit information, releasing only that required by specific requestors. Banks, hospitals, insurance companies, and other corporations would be able to operate securely across open networks, obviating the need for purchasing expensive virtual private network agreements. Workgroups could collaborate with confidence in the security and integrity of their data, using a wide range of platforms and applications.

The implications for defense- and intelligence-related communities are also substantial. In a real-time battlefield setting, any soldier with a radio could transmit vital data to the place it needed to go. The integrity of the transmission would be guaranteed even if the network itself were damaged or tapped. Conversely, command centers, combat vehicles, planes, or other soldiers would know that incoming information was reliable.

The MDA Technology Applications program facilitated Avanza's contact with national security-related institutions, which was one of the reasons why the company moved to the Los Alamos Research Park in New Mexico. Avanza will be working on national security-related projects as well as with a private company in the business of detecting fraud in the oil industry. The company invites interested parties to inquire about licensing and using Managed*i software.

—A. Gruen

Spam-b-gone! *Manage*i security software means less work for the delete key because junk e-mail, also known as spam, would be impossible.*

*Avanza Technologies recently introduced It's M*iMail, an innovative approach to e-mail that gives you full knowledge of who you're communicating with and full control over how you're communicating. To download the free trial, go to http://www.itsmimail.net/.*

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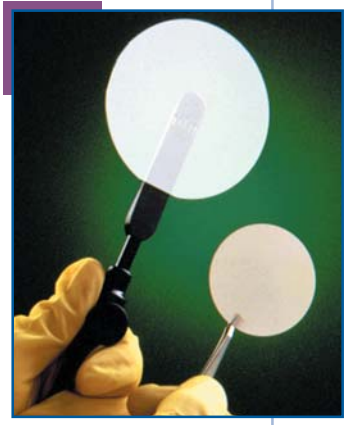
ELECTRONIC MATERIALS

FROM INNOVATIVE RESEARCH TO MISSILE DEFENSE



Growing business. *Initial R&D investments by DOD agencies has enabled Cree's success in developing a wide range of commercially viable silicon carbide wafers and components.*

Cree, Inc. (Durham, NC), has announced that Services and Agencies within DOD, including MDA, have joined forces, awarding contracts totaling $26 million to scale up a manufacturing process for silicon carbide (SiC) microwave monolithic integrated circuits (MMICs). The military has long been interested in Cree's work in SiC because MMIC devices made from such material can perform better than gallium arsenide and microwave tubes for today's radar systems.

The MMIC program should eventually improve the performance and drive down the costs of not only radar amplifiers for defense but also SiC and gallium nitride (GaN) devices sold by Cree Microwave for commercial wireless communications. Cree expects that both the military and commercial products will use the same 3-inch, semi-insulating substrate platform and automated three-inch fabrication facility.

The SiC MMIC program shows the common threads of history that many DOD-funded, innovative technologies share as they progress from research and development to technology insertion into military programs. SiC received support in the mid-to-late 1980's from MDA's predecessor, the Strategic Defense Initiative (SDI), which saw a military use for the material beyond its original application early in the 20th century—sandpaper. A team under Dr. Robert Davis at North Carolina State University (NCSU) came up with a commercially viable process to fabricate SiC wafers. At that time, SDI funded parallel efforts with Dr. Davis' group on a similar class of wide band-gap, nitride-based materials that contributed to this work.

In 1987, a group of NCSU students licensed 10 SiC-related patents and spun out a small company called Cree Research, Inc., focusing on markets for SiC wafers. They received startup funding from SDI's SBIR and Innovative Science and Technology programs, as well as a healthy round of venture capital. With the SBIR program alone, SDI funded more than $4 million, about $2.5 million of which was during Cree's first year.

Silicon carbide is exciting for military systems but its commercial uses are much more lucrative and quite diverse. At the time that the researchers spun out a company from NCSU, blue light emitting diodes (LEDs) were in their infancy. While the world could mass produce red and yellow LEDs, industry could not mass produce the "cooler" colors of shorter wavelength. Cree began to pursue the blue LED market to grow their company and technology, knowing that the use of their technology in high-power switching and radio frequency and microwave communications would take more time to gain acceptance. By 1993, the then-60-employee company filed for an initial public offering, raising $11 million. On February 13, 2003, Cree had over 1000 employees, a $1 billion market capitalization, and $176.7 million in sales to the likes of Osram, which markets them for dashboard lights, market tickers, and large video screens like the one in New York's Times Square. Revenue from the sales of Cree's LED's provided the positive cash flow that it needs to make it through the "valley of death," when R&D funding stops and commercial sales begin.

The new contracts for MMICs bring the DOD closer to capitalizing on its initial investment. Jointly funded by the Navy, MDA and DOD's Title III program through the Air Force Research Laboratory, Cree builds on past improvements in producibility of SiC substrates, epitaxy of SiC wafers, and cleanroom processing for high-power MMIC amplifiers.

Dr. John Palmour, director of Advanced Devices, summed up Cree's success, stating, "We are very excited to see the invaluable initial investments made in Cree by SDI and other DOD agencies coming to fruition. The DOD's early support of Cree gave validity to our technology. Commercial success has in turn added validity to our manufacturing capability, giving the DOD confidence that we can successfully execute this SiC MMIC program."

—L. Aitcheson

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IN THE HEAT OF THE NIGHT

Thermal infrared imagers let you "see" heat, which is particularly useful in detecting hidden objects in near-absolute darkness. But the farther away these objects are, the harder it is to detect their heat signatures.

Structured Materials Industries, Inc. (SMI; Piscataway, NJ), is developing thin-film pyroelectric layers—sensitive enough for use in infrared detector arrays—to improve the performance and reduce the size of thermal infrared imagers. The technology will enable or enhance many night vision monitoring and transportation applications for the military. Raytheon Commercial Infrared is collaborating with SMI on this project.

SMI was funded by BMDO, now MDA, and Raytheon to use its SpinCVD™ technology to develop non-cryogenically cooled, thin-film, pyroelectric infrared detector arrays. SpinCVD is SMI's rotating disk reactor approach to metal organic chemical vapor deposition.

SMI's pyroelectric thin films make smaller and more capable imaging devices because the active layer of the thin film reduces the amount and complexity of the supporting infrastructure required by IR imaging systems. When mature, the pyroelectric thin films will be offered to field systems as upgrade packages. A complete line of new solutions will also be available in multiple commercial product paths impacting public safety, national defense, and consumer products.

SpinCVD uses vaporized precursor chemicals transported into a reactor vessel wherein they decompose at a certain substrate compatible temperature inside the reactor, leaving the desired elements on a substrate or wafer to create a thin film. The main thrust of the SMI program is to make the process temperature as low as possible. The process temperature is important because if it exceeds a certain limit, the substrate—the underlying interconnects, layers, etc.—will start to deteriorate through oxidation, diffusion, or thermally induced contamination or decomposition.

SMI is iterating materials and varying its deposition technique to achieve optimal materials properties at lower processing temperatures. The company is varying the SpinCVD process in three ways to change the temperature. It is changing the precursor chemicals, the implementation methodology, and the processes.

SpinCVD's ability to simplify the supporting infrastructure is also useful in nonvolatile memory and dielectrics for linear devices. "There is an array of oxide applications and there is a growing interest in utilizing our technology for non-oxide materials and tape coatings," said Dr. Gary Tompa, SMI's president.

SMI is currently manufacturing and selling systems for a variety of applications, such as manufacturing thin-film batteries, superconducting films, developing p-type zinc-oxide for electronic devices, and performing research and development. The company has working relationships with Ramtron International Corporation, Argonne National Labs, and the University of Wisconsin at Madison. It also has customers and collaborations with companies in Korea, Japan, and Israel.

SMI is looking for a growth venture partner to help expand its infrastructure to support a larger demand for its technology. The company's focus is on becoming the oxide CVD equipment manufacturer of choice. Most of SMI's customers are small businesses and universities, but the company wants to increase its ability to support the demands of larger customers. SMI currently has a 7,000-square-foot facility with eight demonstration reactors.

—T. Spitzer

Spin is in. *SMI is using a rotating disk reactor approach, called SpinCVD, to deposit oxide and other thin films. Because this equipment processes thin films at low temperatures, no substrate decomposition or contamination occurs.*

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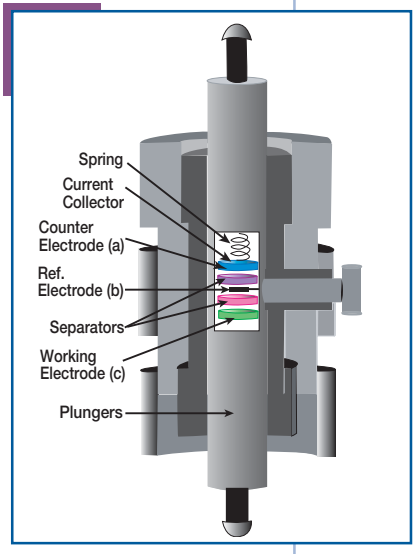
POWER

NANOPOWDERS TO RECHARGE LAPTOP BATTERIES FASTER



Powerful powder. *NEI's nanopowder will enable new lithium-ion batteries that charge and discharge faster, store more energy, and last longer.*

Why wait up to seven hours for your laptop battery to recharge? New batteries that recharge in 30 minutes or less will soon be available, thanks to new nanomaterials research conducted by Nanpowder Enterprises, Inc. (NEI; Piscataway, NJ).

In 2001, BMDO, now MDA, awarded NEI a Phase II SBIR contract to develop a new class of kinetically stabilized nanostructured cathode materials for rechargeable lithium-ion (Li-ion) batteries. MDA is interested in Li-ion batteries with increased capacity at lower cost. NEI demonstrated that the electrochemistry of nanomaterials is very different from conventional coarse powders. Specifically, the internal structure of the nanomaterial particle intercalates Li-ions differently from coarse particles leading to three significant changes in the outcome.

First, the nanopowder particle sizes are 10- to 20-times smaller than lithium cobalt oxide powder, the coarse material used to manufacture most Li-ion batteries today. Smaller nanopowder sizes allow the battery to be charged and discharged faster and more fully. When comparing a 10-micron coarse particle with a 10-nanometer particle, the Li-ion battery fabricated with the nanomaterial is about five to ten times faster. The quicker discharge is useful as well, for example, in an uninterruptible power supply when a sudden burst of charge is required.

Second, the current state-of-the-art Li-ion battery has an energy density of 150 to 175 Watt-hours per kilogram (Wh/kg). NEI nanopowders can potentially increase the energy density of Li-ion batteries to about 250 Wh/kg.

Third, inserting Li-ions inside the cathode material during recharge always creates a volume distortion of the crystal structure. The structure distortion stress in NEI's nanomaterials is significantly reduced, leading to a longer cycle life for the battery. The Li-ions can travel through the structure numerous times before the crystal structure is damaged.

NEI has sold its products and services to approximately 125 customers, mostly for research and development. The company sees tremendous growth for its materials, particularly in rechargeable batteries. According to a market research study by Freedonia Group, the worldwide rechargeable battery pack market—Li-ion, nickel-cadmium, lead-acid, and nickel metal-hydride—is to grow from $4.4 billion in 1999 to $5.8 billion in 2004.

NEI has several industrial partners in its endeavor to bring nanomaterials technology to the Li-ion industry. Some of these collaborators are technology developers, while others are manufacturers.

NEI is currently seeking $3 to $5 million in venture funding to scale up existing processes with equipment purchases and hire technical business development engineers. It also welcomes strategic partnerships that will help further develop its products and bring them closer to market.

—T. Spitzer

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MDA TECHNOLOGY NEWS ON LINE

Is the information below news to you?

- EMCORE acquires Agere Systems' West Coast optoelectronics business.
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- Parallax and EDX agree to develop x-ray spectrometer.
- Advanced Photonix acquires Silicon Sensors.
- Adroit Systems is acquired by SRA International.
- NVE announces listing on NASDAQ Small-Cap Market.
- CLR Photonics installs infrared Doppler radar at Hong Kong International Airport.
- APA Optics agrees to purchase Computer Systems Products.
- RedHawk Vision and Horus Ventures form exclusive partnership to market Video Pics software.

If so, be sure to visit our Web site at www.mdatechnology.net. Under the Company News section, you'll find hyperlinks to more press releases from MDA-funded companies.

POWER

BUILD TO SUIT: DESIGNER POLYMER SURFACES

Display screens of the future may be flexible and wafer-thin, but how will they hold up on the battlefield—or worse yet, under the grubby hands of a four-year-old?

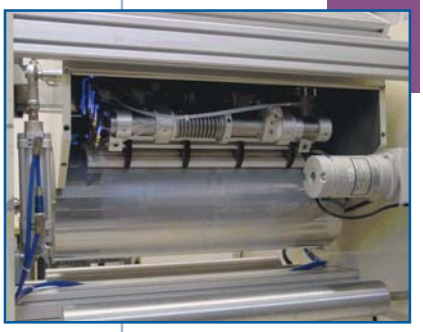
Sigma Technologies International, Inc. (Tucson, AZ), may have found the answer. The same basic process used to coat high-energy-density polymer film capacitors can also be applied to smoothing polyester and creating a glass-like ceramic-polymer barrier layer less than one micron thick. The company has already licensed the non-defense-related aspects of the coating technology to two firms with major shares of the display market.

Since 1993, BMDO, now MDA, as well as DOE funded a series of contracts with Sigma to investigate the potential for high-speed, vacuum-based coating equipment. One area of BMDO interest in particular was pulsed-power energy weapons and the need for ultra-high voltage capacitors. The high dielectric constant of polyvinylidene diflouride (PVDF) was well known and made it the material of choice, but could it be applied as a thin-film surface on capacitors using large-scale manufacturing techniques such as in-line continuous processing? In 1999 and 2000, the company showed that it was indeed possible.

The path to success was a combination of irradiation of the PVDF and coating it with a thin, amorphous acrylate polymer film, producing a single-layer capacitor of power density on the order of five joules per cubic centimeter (J/cc). Commercial capacitors on the market today provide about 2.0 to 2.5 J/cc. According to Sigma, optimizing the radiation curing process, polymer material, and electrode resistivity could in theory produce a single-layer capacitor with power density on the order of 20 J/cc. Coating PVDF with acrylate polymer also has a fringe benefit: it improves the melting point of the PVDF from 150°C to 300°C, enabling the capacitor to handle greater voltage. The coating acts as a skin that helps a metallized capacitor self-heal; otherwise, it would short out.

The company uses a patented technique of exposing a base material such as a film or fabric to a plasma before applying the polymer coating. This process was originally performed in a vacuum. Sigma has licensed the coating process to one of the major suppliers of metallized films for capacitors worldwide. Subsequently, Sigma developed an atmospheric plasma treatment that does not require a vacuum.

Sigma has designed equipment that can process a roll of base material at speeds higher than 1,000 feet per minute. Since PVDF-based film is very expensive with limited applications outside the defense community, Sigma has sought other venues for capitalizing on its expertise in treating base materials and functionalizing polymer coatings. A very promising market is creating multilayer barriers for packaging materials and displays. A multilayer (silicon dioxide or polyester) barrier one micron thick could serve as an effective physical barrier against heat, moisture, and dirt, and yet remain transparent. The implications for the not-yet-mature flexible display or wearable computing industries are considerable. And if the process is truly cost-effective, the food and beverage industry could use a polymer coating as a non-toxic way of extending the shelf-life of many products by placing them in transparent containers.



Tailored coat. *Sigma Technologies' equipment can plasma treat materials at high speed. A very promising market for this technology is designer polymer surfaces.*

Sigma, which sells coating equipment and licenses its manufacturing process worldwide, invites inquiries from any parties interested in the functionalization of polymer coatings. It has not licensed its PVDF-based capacitor technology, however, to keep close control over what is currently a defense-related requirement for high energy pulsed power being discharged within a confined capacitor space. For that specialized purpose, inquiries from U.S. companies are encouraged.

—A. Gruen

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POWER

DUAL-USE SYSTEM COUPLES PROPULSION AND POWER GENERATION

In the works. *MSE's facility houses a prototype magnetohydrodynamic generator for research and development. When completed, the system will provide both power and propulsion on an orbiting platform.*

Most satellite platforms have a continuous power supply for routine needs. However, there are uncommon, out-of-the-ordinary events when a normally dormant satellite system must generate high power in seconds to provide defense and emergency communications.

MSE Technology Applications, Inc. (MSE; Butte, MT), is developing a method of generating propulsion and high electric power simultaneously for short durations. BMDO, now MDA, funded MSE to develop space power generation technology that is based on the coupling of a pulsed detonation rocket engine (PDRE) with a magnetohydrodynamic (MHD) generator. The PDRE-MHD system would provide MDA with a low-cost, dual-use, highly efficient, and flexible design for an orbital power-generating platform, which currently is MSE's main application.

In a PDRE-MHD system, the constant-pressure combustion mode of a conventional rocket is replaced by a constant-volume combustion process, which is achieved by fast, repetitive cycling of the detonation of reactants within a combustion chamber. The MHD generator is established with concentric magnetic coils at a diverging exhaust nozzle of the engine. Because the exhaust gases passing through the nozzle are in an ionized condition, it is possible to generate an electric current. MSE will seed the gases with a chemical compound containing an alkaline metal to make conductive plasma.

The PDRE-MHD will provide directed energy satellite weapon system platforms with multiple, smaller tubes arranged symmetrically and fired synchronously thereby mitigating engine failure rates, vibrations, and costs while, at the same time, increasing survivability and operability. By asymmetrical firing of tubes, the system fully accommodates the dual-use requirements of power generation and orbital maneuvering propulsion.

The second type of platform being considered is an emergency communications satellite. The satellite would only be activated in the event of a communications emergency, such as a missile attack. The PDRE-MHD could be dormant in space for years until it is needed. However, when fired, the device would give a very high power output and orbital maneuvering, if required.

The PDRE-MHD system can be modified for ground-based applications as well. A pulsed detonation engine (PDE) combined with an MHD generator can produce power for ground-based, high-power, short-duration applications, such as energy weapons for theater defense like the space-based PDRE-MHD system, however, it would use a less expensive fuel. MSE is also contemplating using an air-breathing PDE with MHD for continuous power generation; however, this is not an application the company is currently pursuing.

Boeing-Rocketdyne participated as a subcontractor on this project and has expressed interest in the directed energy weapons application, which could be available in three to five years with sufficient funding. MSE is not a manufacturing company, so it needs a licensing partner involved in aerospace to commercialize the technology. MSE is completing a developmental system that will be used for further research and development. The company needs dollar-for-dollar matching funds, up to $300,000 from additional sources so it can use the remaining half of its MDA SBIR Phase II funding to further refine the technology.

MSE is focused on the research, development, and commercialization of aerospace, advanced energy, and environmental technology. The company's main customer is the DOD, but it has performed technology development for several Federal agencies, including MDA. MSE is headquartered in Montana, has six field offices located throughout the United States, and employs 200 people.

—T. Spitzer

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THE DAWN OF SOLAR CELL MASS PRODUCTION

Imagine if solar cells were as lightweight, easy to make, and inexpensive as camera film. It would make solar power generation immediately affordable and desirable.

DayStar Technologies, Inc. (Grass Valley, CA), has developed high performance, low-cost, lightweight, and flexible thin-film solar cells that have both military as well as commercial applications. These cells, which are fabricated on flexible metal substrates, can replace traditional silicon-based solar cells. The breakthrough here is that the flexible, metal substrate enables mass production using a continuous, in-line manufacturing process.

BMDO, precursor to the Missile Defense Agency, originally awarded a Phase I SBIR contract to DayStar in 1999 to see if copper-indium-gallium-diselenide (CIGS) thin-film photovoltaic cells on stainless steel foil could be manufactured instead on an even lighter substrate for use in space assets. The results were very successful: a power-to-weight ratio of over 1,400 W/kg. In 2000, BMDO awarded a follow-on Phase II contract to see if DayStar could reduce manufacturing costs and achieve high-volume production.

The advantage of DayStar's thin-film product is that it is fabricated on thin metal foils instead of rigid glass, simplifying manufacturing and cell interconnections. Foil bends easily, which crystalline silicon wafers cannot do, and can be literally rolled off a spool just like aluminum foil in the kitchen. DayStar's polycrystalline CIGS heterojunction solar cell sandwiches a 1.5- to 2.5-micron thin CIGS absorber layer between the foil substrate at the bottom and the zinc oxide window deposited at the top. The company uses additional film layers as mechanical and chemical buffers to increase production yields.

The continuous in-line manufacturing process and the use of large, flexible metal sheets as the substrate means that cells can be produced to almost any shape and specification. This reduces waste in manufacture and has the potential to dramatically improve profit margins. Additionally, DayStar Technologies believes it would cost significantly less than the competition (about $20 million versus $50 million) to create a plant to produce 100 megawatts per year.

The solar cell market has always been elastic, but on the unfavorable end of the equation: demand from power companies and others seeking alternatives to fossil fuels for solar power is limited because it is relatively expensive, and it tends to remain expensive because market demand remains limited. If DayStar can find capital sources willing to break that cycle, the company can prove that high processing speed can reduce the cost of solar power by 50 percent or more. Once production reaches that low-cost level, a host of potential commercial applications open up for cells including decentralized (home and office) power generation and use in appliances.

Aside from the terrestrial applications, one intriguing possibility for the use of lightweight, flexible, high performance thin-film solar cells is to power airships. The doctrine of using airships as supply vehicles or as platforms for surveillance and reconnaissance missions has historically luffed against a stiff headwind of operations cost and vulnerability. An airship has plenty of surface area, however, making it an ideal candidate for hosting lightweight solar cells. These could power an airship virtually indefinitely and thereby reduce operations costs.

DayStar seeks capital to establish a pilot plant to fabricate cells using the continuous in-line technique. Given sufficient funding, the company hopes to have pilot plant production underway by the end of 2004.

—A. Gruen

Bends easily. *DayStar's solar cells rest on thin metal foil instead of rigid glass. Using continuous in-line manufacturing and large, flexible metal sheets, this technology could significantly increase profit margins for mass production of solar cells.*

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SENSORS

PLASMA ANTENNAS: HIGH ON VERSATILITY, LOW ON VISIBILITY

It disappears. *When the gas in this plasma antenna is not ionized, the antenna element ceases to exist. Ionization is performed only for the amount of time it takes to transmit or receive a signal.*

A Nevada company has developed antennas that use ionized gas instead of metal to transmit and receive signals, decreasing the chance of signal interference while boosting functionality. For commercial users, the devices hold potential for more efficient and more focused transmission of signals—whether in a wireless computer network or in a sprawling cellular network. Meanwhile, for military users, the antennas could enhance the stealth capabilities of aircraft or other vehicles.

The company, ASI Technology Corporation (Henderson, NV), has funded its research into plasma antennas with assistance from MDA's predecessor, BMDO, which originally funded the technology project for its potential in detecting and tracking ballistic missiles. Creating antennas with a lower profile and more capabilities than metal antennas has been a goal of the research. And the result has been an antenna that is lightweight, reconfigurable, stealthy, and resistant to electromagnetic interference. Dr. Ted Anderson, principal investigator of ASI, and Professor Igor Alexeff of ASI have developed theoretical models, conducted experiments, and built prototypes of plasma antennas in the laboratory.

A plasma antenna, according to Anderson, is simply a glass or ceramic tube containing ionized gas. Such an antenna contributes to a superior antenna profile in two key ways. First, since a plasma antenna can be reconfigured dynamically for frequency, direction, bandwidth, gain, and beamwidth, one antenna can do the job of several antennas. Having fewer antennas can decrease clutter and weight on a structure such as a communications tower, as well as on aircraft, spacecraft, or watercraft. Having fewer antennas also means less interference among antennas. For the military, fewer antennas and less interference mean less visibility on enemy radar.

Second, the plasma antenna developed by ASI has an additional feature that makes it less likely to receive or produce unnecessary interference. Metal antennas can pick up interfering signals or noise bounced off of other metal objects—another metal antenna at rest, for example. But since the gas in a plasma antenna is ionized only for the amount of time it takes to transmit or receive a signal, a plasma antenna at rest does not hold the same potential for interference that a metal antenna holds.

Ultimately, the anti-interference qualities of the plasma antenna mean the device offers a better signal-to-noise ratio than a conventional antenna, according to ASI officials. And getting a better signal-to-noise ratio means users require less power when transmitting and receiving signals.

But the product promises even more benefits over conventional antennas. The "on/off" operation of a plasma antenna and its ability to be dynamically reconfigured allows users to steer or focus a signal beam easily, as well as to transmit and receive signals in extremely short pulses—an important quality for many forms of digital communication and radar. The features make the technology especially useful for commercial applications.

A "smart" array of the antennas driven by sophisticated signal-processing software, for example, could help direct signals for cell-phone towers to maximize signal strength and reduce interference. And on a smaller scale, a user of a wireless laptop might control plasma antennas in an array to close or create "windows" through which he could direct a signal. Such focusing would allow the user, for example, to share data with only one fellow wireless-computer user at a meeting, instead of broadcasting the data to all other wireless users in the meeting.

ASI executives continue to study commercial applications of the technology. The company also is searching for ways to produce cheaper, more rugged tubes for the antennas. Company executives continue to explore whether to license their technology or to become a full-fledged manufacturer of plasma antenna systems.

—S. Tillett

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FEATURE

A Glimpse at . . . from page 1

of the guides did not adversely affect their performance. The Army concluded from the results of wear tests that samples offered 2- to 3-times greater wear resistance yet were 45-percent lighter than the standard high-hardness steel used today.

JET Technologies is planning to investigate the formation of nitride composites in zirconium and halfnium and carbide composites in vanadium, niobium, and tantalum. The company is looking for development partners with identified applications.

Machining of Ceramic Materials

Third Wave Systems, Inc. (Minneapolis, MN), is designing a software package to model ceramics machining processes. This tool can be used to identify optimum process conditions for machining ceramics; that is, those that result in reduced machining time and increased yield. The software can be seen as a sophisticated replacement for a machine tool operator's experience or a manufacturing engineer's "book knowledge."

The tool is based on Third Wave System's existing software package, called AdvantEdge™, which can be used to model metal machining processes, such as turning and milling. AdvantEdge provides users with very detailed information on the amount of heat being generated, heat flow, and the characteristics of the machined work piece surface. It can help expose any potential flaws or residual stresses that can adversely affect the quality and performance of machined parts. Notable AdvantEdge customers include Boeing, General Motors, Caterpillar, Ford, and Northrup Grumman.

Third Wave Systems is building on research conducted by John Patten, a professor at the University of North Carolina-Charlotte, who found that brittle silicon germanium materials can be machined using certain cutting-tool geometries and process parameters. Through its MDA SBIR Phase I contract, the company validated Patten's discoveries using silicon nitride.

This innovation will lead to potentially many new applications of ceramic components for automotive, aerospace and machine parts. Industry will benefit economically through significantly reduced testing trials, improved productivity, lower component costs, increased component quality, and expanded manufacturing capability. MDA is interested because the software could substantially reduce the amount of prototyping time needed to create MDA components, such as lenses, mirrors, windows, and radar domes.

Third Wave Systems seeks customers with specific applications or companies interested in forming alliances.

Monitoring Internal Attacks on Computer Systems

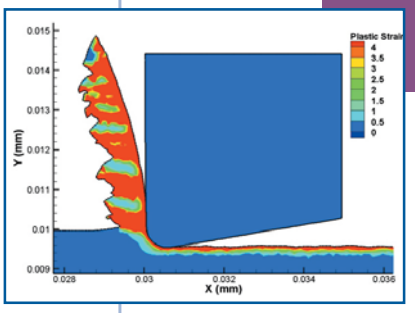
Xfinit, Ltd. (Florence, MA), has developed an algorithm that monitors and detects internal attacks on computer systems. The algorithm monitors the actions of a particular computer user and alerts someone—most likely a security officer—in the event of unusual activity by that user. It operates inside a firewall and can address inside security issues by identifying people who are "fine" one day and "suspicious" the next.

The algorithm works by establishing a baseline for each individual by monitoring that person's activities in an application for a given time period. After the baseline is established, an acceptable variance is entered into the system so that the algorithm can detect when activities fall outside the normal range and alert someone to this fact.

For example, a security officer can easily set up a "sensor" that monitors the frequency of access to an electronic repository of secure documents. The sensor can be configured so that if the frequency of internal access fluctuates no more than 50 percent in a day, no alerts are triggered. However, if the frequency of internal access rises above 50 percent, the sensor will set off an alarm and notify the security officer.

With the technology's multiple sensor capability, information residing on application servers across multiple applications can be grabbed and analyzed, which leads to significant reductions in false alarms—or what industry calls "false positives." An employee may have a valid reason to exceed the 50 percent threshold for accessing the electronic depository, as described above. But the security officer can set up additional sensors, say to monitor travel requests and long distance calls, that provide more data for analysis. Consider this scenario: If multiple sensors detect a per-

Continued on page 16



First cut. *Industry currently lacks the knowledge and ability to model ceramics machining processes. Third Wave Systems is developing prototype software that will allow customers to study, through simulation and process modeling, the manufacturing conditions inherent to the machining of ceramic materials.*

MDA Update
SPRING 2003

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Xfinit believes any organization interested in analyzing anomalous information on computer systems could benefit from its security software.

A Glimpse at . . . from page 15

son exceeding the thresholds for electronic depository access, foreign travel requests, and telephone calls to a particular foreign country, this person might warrant further investigation.

The algorithm has enormous potential as its commercial and military applications are many. For example, Xfinit says that credit card companies, some of which employ hundreds of people to track down false positives, could significantly increase their fraud detection efforts while decreasing labor costs. These companies are using neural network-based security products, which are limited to monitoring one application at a time.

Having completed its MDA SBIR research, Xfinit is actively looking for development partners with potential security applications for this technology.

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NEW REPORT HIGHLIGHTS COMMERCIAL SUCCESS STORIES FOR 2002

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